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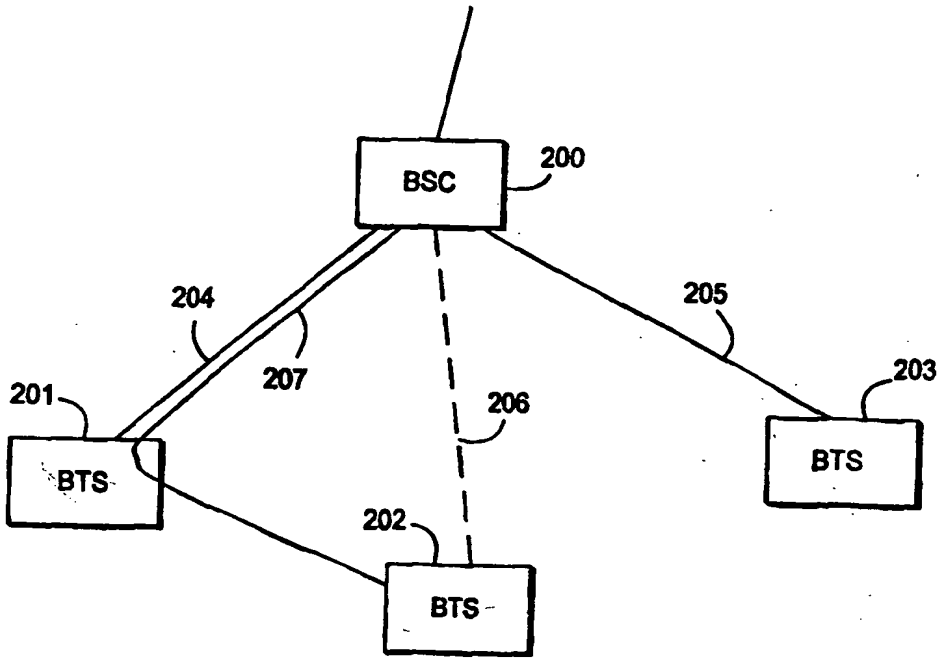
(54) **Title:** AN AIR–INTERFACE CONTROLLED BASE STATION FOR A CELLULAR RADIO NETWORK

(57) **Abstract**

In a cellular radio system the operation of each base transceiver station (201, 202, 203) is controlled by a base station controller (200) and the base transceiver stations comprise means for providing the terminals of the cellular radio system with an air interface. At least one base transceiver station (202) further comprises means for routing information (207) transferred between the base transceiver station (202) and base station controller (200) via the air interface.



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An air-interface controlled base station for a cellular radio network

The invention relates in general to the operation and control of a base station in a cellular radio system. In particular the invention relates to the realization in different appropriate manners of the transfer of information between a base station and other network elements. A mobile telephone system will be used as an example of a cellular radio system.

A base station subsystem (BSS) in a digital cellular radio system comprises base transceiver stations (BTS) and a base station controller (BSC) which controls several base transceiver stations simultaneously. Fig. 1 shows a known base station subsystem which comprises a base station controller 100 and three base transceiver stations 101, 102 and 103. In the system depicted, the communications links between the base station controller 100 and base transceiver stations 101, 102 and 103 are realized in a star topology where separate communications links branch at the base station controller100 to each of the base transceiver stations 101, 102 and 103. Other known connection topologies include the tree topology, in which a trunk line starting from the base station controller branches from a base transceiver station to another, and the ring topology in which the base transceiver stations and the base station controller are interconnected so as to form a ring-like system. Various combinations and modifications of these basic topologies are also used.

A communications link between a base station controller and a base transceiver station is used for transferring both payload information and various control information internal to the base station subsystem. Typical payload information could be e.g. speech data transferred through a mobile telephone connection. Physically the link may comprise a wire, fiber-optic cable, directional microwave link or a combination of these. In areas with a high density of base transceiver stations and heavy loading on the cellular radio system, sufficient cable and/or microwave link capacity should be reserved for the communications links internal to the base station subsystem to realize a communication network dedicated for that particular purpose. In a known implementation the bit rate in the network is 2048 kbps or its multiple, and the capacity is time-divided into 32 time slots which may be allocated to base transceiver stations in variable quantities. If however a base transceiver station is very far away from the base station controller or traffic via that base transceiver station is at a low level, it may be more cost-effective to use a ready-built communications system such as the ISDN (Integrated Services Digital Network) to provide for communication between the base transceiver station and base station controller.

Finnish Patent Application FI-940034 discloses an arrangement for using an ISDN link for the communication between base transceiver stations and a base station controller.

In the latter case the costs for the communication between a base transceiver station and base station controller may become unreasonably high from the system operator's point of view. If a base transceiver station is for a long time idle, i.e. no connections are established via it which carry payload information, the communications capacity between it and the base station controller may be kept reserved unnecessarily, which results in costs. Application FI-940034 proposes that the ISDN link between a base transceiver station and base station controller may be terminated when there are no calls, but this does not solve the problem entirely: control information must also be transferred between the base transceiver station and base station controller and the base transceiver station must be kept in synchronization with the rest of the system for the multiple access methods to function properly, for example.

An object of the present invention is to provide a method and apparatus for controlling a base transceiver station in such a manner that the disadvantages described above which are characteristic of the prior art will be avoided. Another object of the invention is to provide a method and apparatus for controlling a base transceiver station in a flexible manner adaptable to varying communications needs.

The objects of the invention are achieved by controlling the operation of a base transceiver station by means of a second base transceiver station through the air interface.

A base transceiver station according to the invention is characterized in that it comprises means for routing information transferred between a base transceiver station and base station controller through the air interface.

The invention is also directed to a cellular radio system which is characterized in that it comprises, in a base station controller, means for directing information meant for a first base transceiver station to a second base transceiver station, and in the second base transceiver station means for transmitting via said air interface information received from the base station controller meant for the first base transceiver station.

The invention is further directed to a method for controlling the operation of a base transceiver station. The method according to the invention is characterized in that

information between a first base transceiver station and base station controller is transferred between the first base transceiver station and second base transceiver station via said air interface.

In accordance with the invention, at least one base transceiver station in the cellular radio system comprises means for receiving control commands via the same interface that is normally used for establishing radio links between the base transceiver station and terminals. In addition, at least one other base transceiver station comprises means for transmitting via the air interface control commands received from a base station controller meant for the first base transceiver station.

In the preferred embodiment of the invention a base transceiver station controlled via the air interface may establish an ISDN Basic Rate connection or another link via an existing communications network with a base station controller, but this link is only used when it is needed e.g. to transfer payload information. If the so-called link BTS via which the control commands are relayed has unused capacity, said ISDN or another link need not be established even for the transfer of payload information but the call or another connection requiring transfer of payload information may be routed via the air interface in the same manner as control information. When the link BTS no longer has enough capacity or a predetermined capacity limit is exceeded, a direct communications link with the base station controller is established and the routing of information is transferred from the link BTS to the direct link. When the amount of information transferred via the direct communications link drops so low that it could again be relayed via the link BTS without exceeding said capacity limit, the direct link may be terminated and information may again be transferred via the link BTS. Some sort of hysteresis should perhaps be applied between the limit values for the establishing and terminating the direct communications link lest the direct link be repeatedly switched on and off in rapid succession in a situation where the amount of information transferred just exceeds the limit value for establishing the link.

An advantage of the invention is that it saves costs as there is no need to establish an ISDN link or another direct link between a base transceiver station and base station controller to transfer control, maintenance and synchronization information.

The invention is now described in more detail, referring to the preferred embodiments presented by way of example and to the attached drawing in which

Fig. 1 shows a base station subsystem according to the prior art,

Fig. 2 illustrates the principle of the invention, and
Fig. 3 shows a base transceiver station according to the invention.

Above, in conjunction with the description of the prior art, reference was made to Fig. 1, so below in the description of the invention and its preferred embodiments reference will be made mainly to Figs. 2 and 3.

Fig. 2 shows a base station subsystem comprising a base station controller 200 and three base transceiver stations 201, 202 and 203. Base transceiver stations 201 and 203 are linked 204, 205 in a fixed manner with the base station controller 200 but the link 206 between base transceiver station 202 and base station controller 200 only exists when needed, which is why it is depicted by a dashed line in the figure. Let link 206 be an ISDN link, for example. In that case the establishment of the link as needed means that the base station controller 200 and base transceiver station 202 comprise an ISDN data adapter or a corresponding device by means of which both of them can be connected to a local ISDN exchange. However the link is not continually active, but only if one of the devices 200 and 202 wishes to send information to the other via an ISDN link, it dials the ISDN number of the other device by means of its ISDN data adapter whereby a link is established via a local ISDN exchange in the same manner as an ISDN link normally between two ISDN subscribers. When the link is off, it does not reserve ISDN network capacity so that the only costs caused by it are the potential ISDN subscription rates.

In accordance with the invention, there is a communications link 207 between the base transceiver station 202 and base station controller 200 also via base transceiver station 201, which in this patent application is called a link base transceiver station. Between the base station controller 200 and link BTS 201 the communications link 207 uses the same physical transmission medium as communications link 204. Between the link BTS 201 and base transceiver station 202 a radio link is used in substantially the same frequency band which is normally used for the communication between base transceiver stations and terminals. The communications link 207 is intended especially for the transfer of control information between base transceiver station 202 and base station controller 200, but it may also be utilized for the transfer of payload information.

As far as the link BTS 201 is concerned the communications link 207 may be like any link with a terminal in the cell of the link BTS 201. A certain portion of the communication capacity between the link BTS 201 and base station controller 200 and a certain bi-directional traffic channel available to the link BTS 201 are

reserved for the communications link 207 in the same manner as for each of the active communications links in which the other party is a terminal in the cell of the link BTS 201. In addition to or instead of traffic channels it is possible to use various control channels defined in the system. Downlink data are directed to a transmitter unit in the link BTS 201 which transmits the data through an antenna in the link BTS 201 in the downlink portion of the traffic channel reserved for the communications link 207. At base transceiver station 202 a receiver unit is tuned so as to receive data on that traffic channel. Internal arrangements in base transceiver station 202 direct the received data to a control block in base transceiver station 202. Similarly, uplink data sent by the control block in base transceiver station 202 are transmitted by a transmitter block in base transceiver station 202 in the uplink portion of said traffic channel and received at the link BTS 201 and directed to the base station controller 200. The difference between the radio link between base transceiver station 202 and link BTS 201 and a conventional radio link with a terminal is that since the distance between base transceiver station 202 and link BTS 201 may be relatively great, a transmission power higher than usual or a special directional antenna may be required.

Fig. 3 shows in the form of simple block diagram a base transceiver station 300 in which the invention is applicable. The operation of the base transceiver station 300 is controlled by a control unit 301 which preferably is a microprocessor; the program executed by it is stored in memory 302. To provide an air interface the base transceiver station 300 comprises a transmit antenna 303 and receive antenna 304. Signals to be transmitted are generated in transmitter blocks 305 and directed via a combining means 306 to the transmit antenna 303. Signals received through the receive antenna 304 are distributed via a splitting means 307 to receiver blocks 308. The transmitter and receiver blocks may be physically combined as transceiver blocks (not shown). For wired communication the base transceiver station 300 has a data adapter 309. Data communication internal to the base transceiver station occurs via a bus 310. Thicker arrows in the figure represent direct command links between the control unit 301 and other blocks.

Let first the base transceiver station 300 function as a link BTS so that the data adapter 309 may be e.g. an interface unit, or a so-called transmission unit, in a 2048-kbps transmission system. Via said unit the base transceiver station 300 has received from a base station controller operating instructions for operating as a link BTS, so that at least one downlink channel through a transmitter unit 305 and at least one uplink channel through a receiver unit 308 are reserved for controlling a

second base transceiver station via the air interface. The control block 301 knows which portion of the communication capacity between base transceiver station 300 and base station controller is reserved for controlling the second base transceiver station so that the control block 301 controls the reading and writing of data on bus 310 as well as the operation of the transmitter and receiver blocks in question in such a manner that the downlink data meant for the second base transceiver station are transmitted on the correct downlink channel and the uplink data coming from the second base transceiver station are received on the correct uplink channel.

Let it next be assumed that the base transceiver station 300 functions as a base transceiver station controlled via the air interface. In that case the data adapter 309 may be an ISDN data adapter, which is known per se. In this case, too, the control block 301 controls the reading and writing of data on bus 310 as well as the operation of the transmitter and receiver blocks in question in such a manner that the data meant for the link BTS are sent on the correct uplink channel and the downlink data coming from the link BTS are received on the correct downlink channel. Let it further be assumed that at the moment there exists no active communications link via base transceiver station 300 to any terminal. When the receiver unit 308 receiving control information from the link BTS writes the received data onto the data bus 310, the control block 301 reads them from the bus and stores them in the memory 302 for later use. The control block 301 reads the data to be sent to the base station controller from the memory 302 and writes them to the data bus 310 from which a transmitter unit 305 reads them and sends them to the link BTS.

In an embodiment where all payload traffic between base transceiver station 300 and base station controller occurs via a wired link the ISDN data adapter 309 is activated when the control block 301 informs it about the establishment of an uplink connection required by a terminal or when a downlink paging message for setting up a call connection with a terminal arrives via the ISDN line. In the connection set-up phase the control block 301 changes the read and write order on bus 310 such that the ISDN data adapter 309 reads from the bus the data written by the receiver unit 308 associated with the payload connection to be established and, on the other hand, a transmitter unit 305 associated with the payload connection reads from the bus the data written by the ISDN data adapter 309. The ISDN link may be closed down when the payload traffic between base transceiver station 300 and base station controller has ceased.

In an embodiment where the payload connection may be directed via the link BTS, the operation is different. When a terminal sends a request for setting up an uplink

payload connection, the request is directed via a receiver unit 308, which receives connection requests, to the control block 301 which generates a capacity allocation request and sends it via a transmitter unit 305 to the link BTS wherefrom the request is further directed to a base station controller. If the link BTS has enough free capacity the base station controller issues an affirmative response which is directed via the link BTS and a receiver unit 308 to the control block 301. The control block 301 then changes the read and write order on bus 310 such that the transmitter unit which maintains the connection with the link BTS, reads from the bus the data written by the receiver unit 308 which maintains the connection with the terminal, and, on the other hand, the transmitter unit 305 which maintains the connection with the terminal, reads from the bus the data written by the receiver unit which maintains the connection with the link BTS.

C'est le BSC public qui gère la capacité ≠ notre BSC intégrée

Had the base station controller found the capacity of the link BTS insufficient, the ISDN data adapter 309 would have been activated for the connection requested by the terminal, and the read and write order would have been set in the same way as described above for the previous embodiment. A downlink connection causes corresponding bus read and write order changes; checking of the link BTS capacity status takes place at the base station controller when the downlink connection request arrives there from the network.

In an embodiment where a payload connection may be directed via the link BTS, many alternative methods are applicable to the termination of the ISDN link. In accordance with an advantageous method, the system always attempts to set up a new payload connection via the link BTS regardless of whether the ISDN link is in use or not. If a previously established payload connection is directed via the ISDN link and the above-described new connection set-up attempt based on a capacity allocation request is successful, only the previously established connection will remain on the ISDN link; when it is terminated the ISDN link may be closed down even if the more recent payload connection were still active. In an alternative method an attempt is made to establish the new connection via the ISDN link if it is already in use. In that case the ISDN link is closed down only when all payload connections between the base transceiver station and base station controller have been terminated.

A special case of control information received by base transceiver station 300 is synchronization, whereby the timing of the operation of the base transceiver station is accurately paced with the operation of the rest of the cellular radio system. Syn-

chronization may be realized through the air interface via a link BTS, or an ISDN link with the base station controller may be established intermittently for it.

The embodiments described above are meant to serve as examples and they do not limit the invention. One modification within the scope of the invention is to chain the air interface control for base transceiver stations such that a base station controller communicates with a first base transceiver station via a wired link, and the first base transceiver station communicates with a second base transceiver station via a radio link, and the second base transceiver station communicates with a third base transceiver station via a radio link and so on; this way it is possible to create a system that covers a given portion of a road system, for example. Furthermore, the invention does not necessitate that information transfer via a link BTS and via a direct communications link be mutually exclusive options, but e.g. control information of a base transceiver station may be communicated via a link BTS at the same time that payload information is transferred via a direct communications link.

Claims

1. A base transceiver station (300) to be used in a cellular radio system in which the operation of each base transceiver station (201, 202, 203) is controlled by a base station controller (200), said base transceiver station comprising means (303, 304, 305, 306, 307, 308) for providing the terminals of the cellular radio system with an air interface, **characterized** in that it comprises means (301, 302, 303, 304, 305, 306, 307, 308, 310) for routing (207) information transferred between the base transceiver station and base station controller via said air interface.

2. A base transceiver station according to claim 1, **characterized** in that it also comprises means (309) for routing information transferred between the base transceiver station and base station controller via a wired link (206) when necessary.

3. A base transceiver station according to claim 2, **characterized** in that it comprises an ISDN data adapter (309) for routing information transferred between the base transceiver station and base station controller via an ISDN link (206) when necessary.

4. A cellular radio system which comprises a first base transceiver station (202) and a second base transceiver station (201), comprising means for providing the terminals of the cellular radio system with an air interface, and a base station controller (200) for controlling the operation of said base transceiver stations, **characterized** in that it comprises in the base station controller (200) means for directing information intended for the first base transceiver station (202) to the second base transceiver station (201), and in the second base transceiver station (201) means for transmitting information (207) received from the base station controller intended for the first base transceiver station via said air interface.

5. A cellular radio system according to claim 4, **characterized** in that it comprises means for providing a wired link (206) between the base station controller and first base transceiver station when necessary.

6. A cellular radio system according to claim 5, **characterized** in that said wired link (206) is an ISDN Basic Rate connection.

7. A method for realizing data communication between a base transceiver station (202) and base station controller (200) in a cellular radio system which comprises a base station controller and a first base transceiver station (202) and a second base transceiver station (201) which comprise means for providing the terminals of the

cellular radio system with an air interface, **characterized** in that information (207) between the first base transceiver station (202) and base station controller (200) is transferred between the first base transceiver station (202) and second base transceiver station (201) via said air interface.

8. A method according to claim 7, **characterized** in that in response to a situation where a predetermined amount of information transferred between a first base transceiver station (202) and base station controller (200) is exceeded, a direct communications link (206) is established between the first base transceiver station (202) and base station controller (200).

9. A method according to claim 8, **characterized** in that in response to a situation where a direct communications link (206) between a first base transceiver station (202) and base station controller (200) has been established and the amount of information transferred between the first base transceiver station (202) and base station controller (200) remains below a predetermined limit, the direct communications link (206) between the first base transceiver station and base station controller is terminated.

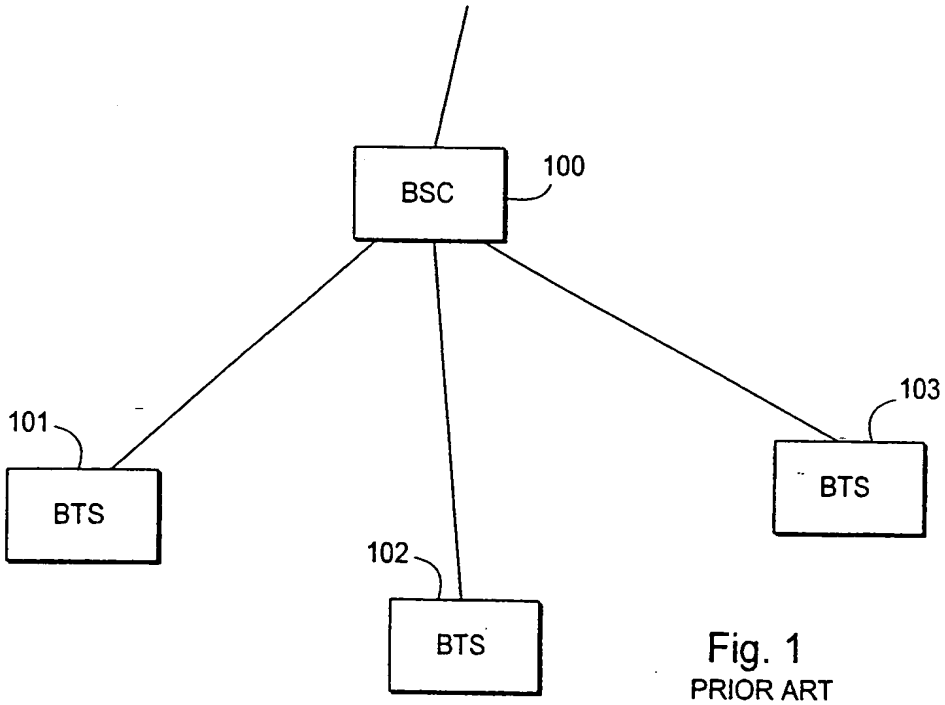

Fig. 1
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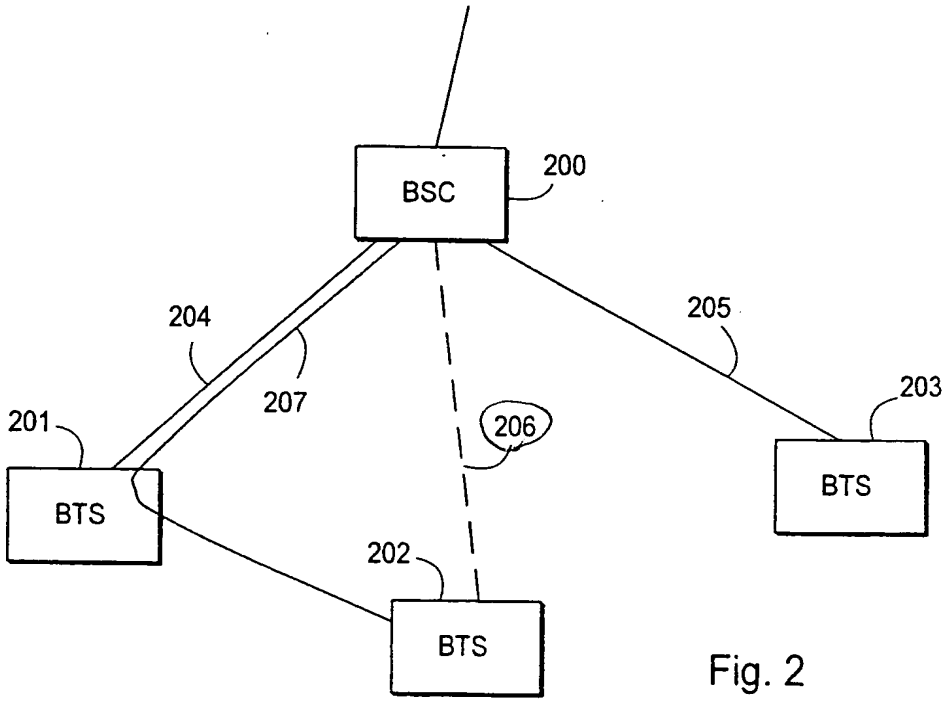

Fig. 2

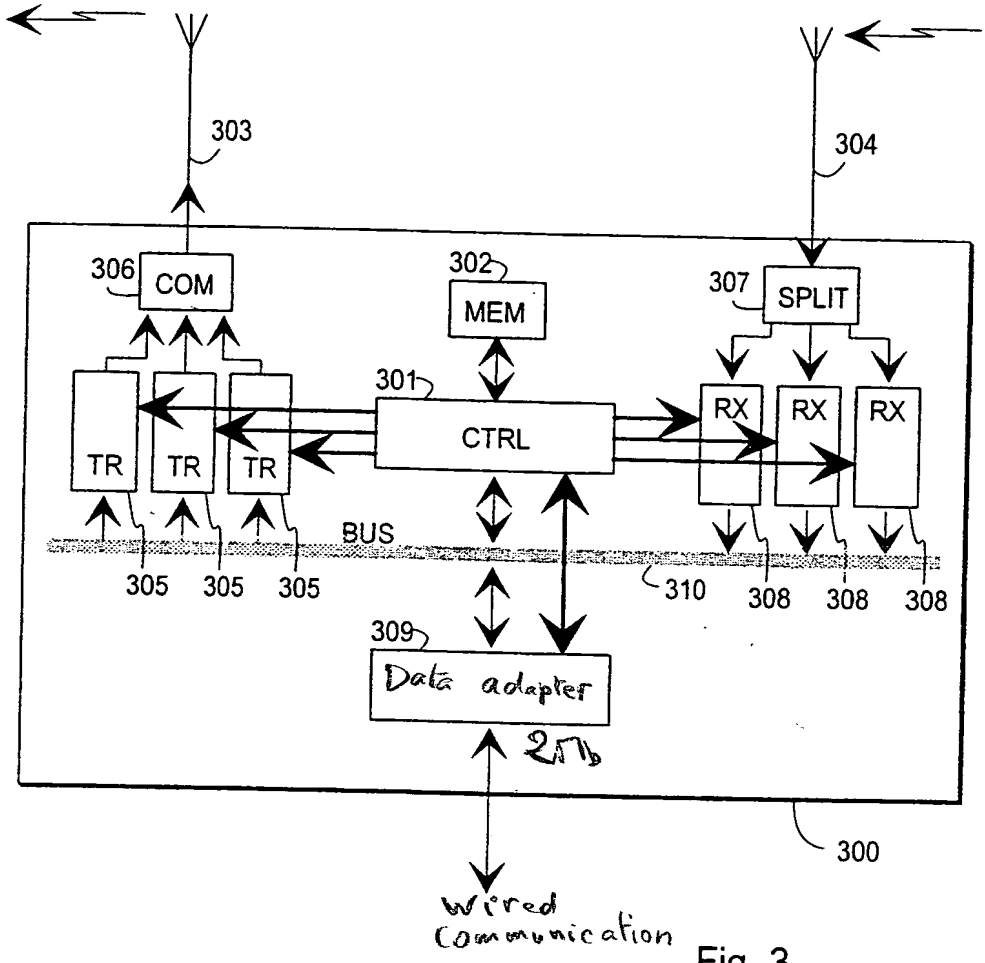

Fig. 3

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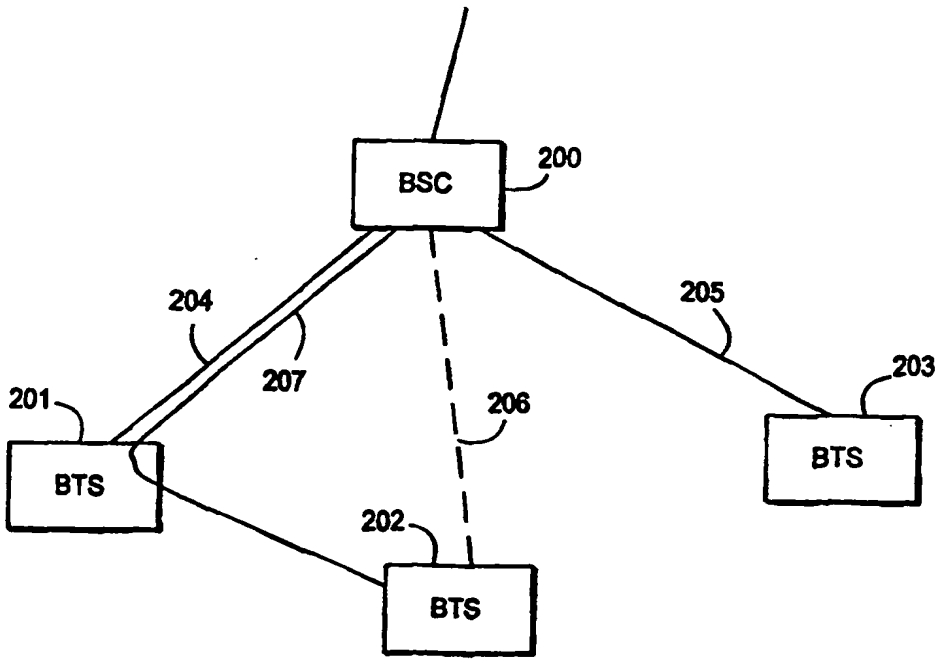
(57) Abstract

In a cellular radio system the operation of each base transceiver station (201, 202, 203) is controlled by a base station controller (200) and the base transceiver stations comprise means for providing the terminals of the cellular radio system with an air interface. At least one base transceiver station (202) further comprises means for routing information (207) transferred between the base transceiver station (202) and base station controller (200) via the air interface.



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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00166

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/30
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2282299 A (MOTOROLA LIMITED), 20 March 1995 (20.03.95), page 6, line 8 - line 20, figure 1	1,4,7
Y	--	2,3,5,6,8,9
Y	WO 9704615 A (BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY), 6 February 1997 (06.02.97), page 2, line 10 - line 21, abstract	2,3,5,6,8,9
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X	WO 9637061 A1 (SOUTHERN METHODIST UNIVERSITY), 21 November 1996 (21.11.96), page 18, column 2	1,2,4,5,7
A	--	3,6,8,9

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
31 August 1999	07 . 09 . 1999
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Per Källquist/cs Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00166

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0468688 A2 (AMERICAN TELEPHONE AND TELEGRAPH COMPANY), 29 January 1992 (29.01.92), figure 1, abstract	1,4,7
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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/08/99

International application No.
PCT/FI 99/00166

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